Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

A99.9 F764Un

Office of Information
PSW

Research Note RM-504

March 1991

USDA Forest Service
Rocky Mountain Forest and
Range Experiment Station

Upward Advance, Intensification, and Spread of Dwarf Mistletoe in a Thinned Stand of Western Larch

Ed F. Wicker and Frank G. Hawksworth[1]

PSW FOREST EXP
APR 12 1991
STATION LIBRARY

From 1978 to 1988 western larch (*Larix occidentalis*) in a thinned, 35-year-old stand in the Coram Experimental Forest, Flathead National Forest in northern Montana, grew an average of 37 cm per year in height. This growth rate was over 4 times the rate of upward advance of dwarf mistletoe (*Arceuthobium laricis*) in these trees, which was only 9 cm per year. Current levels of dwarf mistletoe infection are too low (dwarf mistletoe ratings of only 1 or 2) to reduce tree height or diameter growth, although spread from inoculated trees to previously uninfected ones has occurred at all three spacing levels tested. These findings are discussed in relation to management of dwarf mistletoe in young monocultures of western larch.

Keywords: *Arceuthobium laricis, Larix occidentalis*

Introduction

Because no information was available on the rates of upward advance, intensification, or spread of larch dwarf mistletoe (*Arceuthobium laricis* (Piper) St. John) in thinned, pure stands of western larch (*Larix occidentalis* Nutt.), this study was initiated in 1968 on the Coram Experimental Forest, near Coram, Flathead County, Montana. In other host-parasite combinations, dwarf mistletoes have annual upward advances ranging from 7 to 70 cm (table 1). Filip et al. (1989) reported that thinning can be effective in reducing dwarf mistletoe damage in western larch.

Objectives of this study were to determine for larch dwarf mistletoe the rates of upward advance, intensification (increase of the numbers of infections within a tree), and spread (movement of the pathogen from one tree to another) in stands thinned to three levels of stocking. Wicker and Wells (1983) summarized the findings from the first 10 years (1968–1978) of this study; here we describe the results from analyses of data collected for the second 10-year period (1978–1988).

[1]*Assistant Director and Plant Pathologist, Rocky Mountain Forest and Range Experiment Station. Headquarters is in Fort Collins, in cooperation with Colorado State University.*

Methods

The study was established in a 15-year-old western larch stand in the *Xerophyllum tenax* phase of the *Abies lasiocarpa/Clintonia uniflora* habitat type. The stand originated from natural regeneration following a broadcast burn of a clearcut harvest area. Site index is about 55 feet (16.7 m) at base age 50 years. Details on study history and design appear in Wicker and Wells (1983). In brief, a randomized block design with three replicates was used; each block consisted of three 0.4-ha plots. In each replicate, the plots were thinned to stocking levels of either 1680, 549, or 272 stems per hectare (2.4 by 2.4 m, 4.3 by 4.3 m, and 6.0 by 6.0 m spacing, respectively). There was no natural dwarf mistletoe within about 100 m of the study area. A row of trees along the contour in the center of each plot was selected for inoculation. A total of 94 trees were inoculated. The number of trees inoculated on each plot varied with the intensity of thinning: 13–14 for the 2.4-m spacing, 7–8 for the 4.3-m spacing, and 5–7 for the 6.0-m spacing. The trees were inoculated in 1968 with dwarf mistletoe seeds collected from western larch near Growden, Washington. Each tree was inoculated with 30–50 seeds on branches at heights of 0.6 to 2.1 m. Repeat inocula-

Table 1.—Literature on upward advance of dwarf mistletoes.

Arceuthobium, host, and location	Mean upward spread (cm/year)	Reference
A. spp., Pacific Northwest	10	Graham 1967
A. abietinum on red and white firs, California	7	Scharpf and Parmeter 1976
A. occidentale on digger pine, California	70	Hawksworth 1969
A. tsugense on western hemlock,		
British Columbia	30 (dense stand) 65 (open stand)	Richardson and van der Kamp 1972
Alaska	21	Shaw and Hennon 1991
A. vaginatum ssp. *cryptopodum* on ponderosa pine, Arizona	10	Hawksworth and Geils 1985

Table 2.—Ten-year (1978–1988) diameter growth, height growth, and upward advance of dwarf mistletoe in inoculated western larch trees.

Spacing Replication	Number of trees	Diameter growth	Height growth	Upward advance
		cm	*m*	*m*
2.4 by 2.4 m				
1	5	3.7 ± 1.3	3.34 ± 1.06	0.38 ± 0.44
2	5	4.0 ± 1.3	3.00 ± 1.27	0.10 ± 0.38
3	12	4.5 ± 1.2	4.17 ± 0.67	1.51 ± 1.71
Subtotal	22	4.2 ± 1.3	3.72 ± 0.98	0.93 ± 1.42
4.3 by 4.3 m				
1	2	6.7 ± 2.0	4.65 ± 1.06	0.35 ± 0.49
2	2	2.6 ± 0.7	2.65 ± 1.06	1.15 ± 0.78
3	7	5.2 ± 1.1	3.71 ± 0.91	1.04 ± 0.77
Subtotal	11	5.0 ± 1.7	3.69 ± 1.06	0.94 ± 0.72
6.0 by 6.0 m				
1	4	4.6 ± 1.4	2.52 ± 0.60	0.87 ± 0.28
2	2	5.3 ± 0.6	5.35 ± 0.49	0.15 ± 0.35
3	1	6.1	4.40	1.20
Subtotal	7	5.0 ± 1.2	3.60 ± 1.46	0.71 ± 0.47
Total	40	4.6 ± 1.4	3.69 ± 1.07	0.89 ± 1.12

tions with the same number of seeds were made in 1972 on 17 trees in which few infections developed from the 1968 inoculations. In 1988, the 40 remaining inoculated trees were measured to record 10-year (1978–1988) height growth, diameter growth, and upward advance of mistletoe.

In the earlier examinations (Wicker and Wells 1983), the number of dwarf mistletoe infections present on each tree was recorded. In 1988, however, tree dwarf mistletoe ratings (DMR) were determined by the 6-class rating system (Hawksworth 1977). In this system, the live crown of a tree is visually divided into thirds, and each third is rated as: 0 = no visible infection, 1 = light infection (less than half of the branches in the third is infected), or 2 = heavy infection (more than half of the branches in the third is infected). The three ratings are then added to obtain a tree rating. For example, a tree rated as heavy in each third would be Class 6.

In 1988 all uninoculated trees that had become infected were also rated for dwarf mistletoe, and the distance to the nearest inoculated tree was determined.

Results

As Wicker and Wells (1983) noted, black bears had killed 17 inoculated trees by 1978. Bear-caused mortality continued into the early 1980's, killing an additional 34 trees, which left only 43 of the original 94 trees alive in 1988. Of these, 2 were bent over by snow and 1 was a subalpine fir (*Abies lasiocarpa* (Hook.) Nutt); thus, only 40 of the originally inoculated western larches remained for analyses after 20 years.

Upward Advance of Dwarf Mistletoe vs. Tree Growth

Neither tree height growth, tree diameter growth, nor upward advance of dwarf mistletoe differed significantly among spacing treatments (table 2). Upward advance in the 40 trees for the 10-year (1978–1988) period ranged from −0.6 to + 5.0 m (minus figures result when previously infected branches die, usually because of shading).

10-year upward advance (meters)	Number of trees
–0.6–0	11
0.1–1.0	14
1.1–2.0	11
2.1–3.0	2
3.1–4.0	1
4.1–5.0	1

For the same period (1978–1988) the mean 10-year height growth of the 40 trees was 3.69 ± 1.07 m, whereas the mean upward advance of mistletoe was 0.89 ± 1.12 m (table 2). Thus, the trees grew about 4 times faster in height than the dwarf mistletoe advanced upward. The mean upward advance of the mistletoe for 1978–1988 was about 9 cm per year, while that for these same 40 trees from 1975–1988 was 12 cm per year.

Diameter growth of the trees between 1978–1988 ranged from 2.6 to 6.1 cm (average 4.6 cm) and was not correlated with spacing (table 2).

Dwarf Mistletoe Intensification

The 6-class dwarf mistletoe ratings were not recorded until the 1988 examination, but they were undoubtedly very low before because the inoculations were only made in the lower crowns. The 1988 ratings were still low (DMR Class 1, 24 trees; DMR Class 2, 15 trees; and DMR Class 3, 1 tree) for an average dwarf mistletoe rating of 1.4.

Tree-to-Tree Spread

By 1978 dwarf mistletoe had spread to 81 uninoculated trees (Wicker and Wells 1983). Many of these were killed by bears, and in 1988 only 54 "spread" trees were recorded (table 3). Distances of these trees from the nearest inoculated tree ranged from 0.5 to 4.7 m. No differences in the mean distance of tree-to-tree spread in relation to thinning level were evident from analysis of the 1988 data (table 3). The average mistletoe rating of the spread trees was only 1.1 (48 Class 1 trees and 6 Class 2 trees).

Discussion and Conclusions

The high levels of bear-caused mortality among the study trees left only 40 of the original 94 by 1988. This loss has seriously compromised the study's original purpose and limited its utility, making it difficult to definitely conclude meaningful relationships from the restricted data base.

The average tree height growth rate from our study (39 cm per year) is comparable to that in young, thinned, uninfected western larch stands in eastern Oregon (Seidel 1984).

Because of the long incubation period of dwarf mistletoes (Hawksworth and Wiens 1972), it takes some time after inoculation for populations to build up and, thus, before significant upward advance can occur. In their study, Wicker and Wells (1983, fig. 1) showed that there was essentially no upward advance prior to 1975, but that it increased rapidly between 1975 and 1978. For the 40 trees alive in 1988, the 13-year period 1975–1988 upward advance averaged 12 cm per year.[2] This rate is comparable to the 13.5 cm per year recorded for 77 trees from 1972 to 1978 (Wicker and Wells 1983). The 1978 to 1988 results, showing an upward advance of 9 cm per year, suggest that the rates of upward advance may be slowing as the trees age. Growth characteristics of the host and the parasite may affect this variable.

Crown closure has not yet occurred for any of the spacings. The individual and combined decade values for mean annual upward movement are all well above the "critical value threshold" (when tree height growth equals the rate of upward advance of the mistletoe (Richardson and van der Kamp 1972)) for all spacings studied. The 4-factor mean annual height growth of trees over the upward movement of the pathogen is expected to be maintained until crown closure.

Although the mean, 10-year upward advance was less than 1 m, it was over 2 m in 4 trees (10% of the total) and 5 m in one tree. However, in all cases, the rate of upward advance of the mistletoe was less than these infected trees' height growth. Although most infections will probably be confined to the lower crowns, occasional infections can occur quite high; and if such infections happen to be in female plants, they could lead to local intensification.

Initially, numbers of infections were used as a measure of intensification. This method is practical only for small, lightly infected trees. Because of increased numbers of infections, changes in vertical distribution of infections, and increased tree heights, it was not possible

[2]*Tree height data for 1975 are not available so we cannot directly compare tree height growth vs. upward advance of mistletoe for the entire 13-year period.*

Table 3.—Lateral spread of dwarf mistletoe from inoculated western larch trees to adjacent trees.

Spacing	Number of trees	Maximum spread	Mean spread and standard deviation
m		*m*	*m*
2.3 X 2.3	31	4.7	2.5 ± 0.8
4.3 X 4.3	14	4.4	2.7 ± 1.1
6.0 X 6.0	9	4.2	2.4 ± 1.1
Total	54	4.7	2.5 ± 0.9

to obtain an accurate count of infections in the 1988 examination. Thus, we used the 6-class system (Hawksworth 1977) to measure intensification and establish a base line of data for future reference.

The data sets from the 1978 and 1988 remeasurements are not directly comparable. Statistical comparisons could not be made so these data are not used for conclusions on intensification. However, the fact that inoculations were confined to the lower one-third of the crown and infections in some trees now occur in the middle one-third are indicative of intensification.

In the first decade of the study, the pathogen spread from the inoculated trees to adjacent trees in all three stocking levels. A total of 81 adjacent trees were identified in 1978 as infected through primary spread from the inoculated trees. Many of these trees were lost from the study because of girdling by bears; there were only 54 "spread" trees present in 1988. These data are confounded by the high mortality of the original leave trees and original spacing has become obscured by ingrowth. Even so, the study does demonstrate that spacings up to 6 m will not prevent tree-to-tree spread.

Acknowledgments

We thank Jim Byler and Laura Merrill, Forest Pest Management, USDA Forest Service, Northern Rocky Mountain Region, Missoula, MT, for assistance in the 1988 remeasurements of the plots. We also acknowledge Wyman Schmidt of the Intermountain Station and Greg Filip of the Pacific Northwest Station for reviewing the manuscript.

Literature Cited

Filip, G. M.; Colbert, J. J.; Parks, C. A.; Seidel, K. W. 1989. Effects of thinning on volume growth of western larch infected with dwarf mistletoe in northeastern Oregon. Western Journal of Applied Forestry. 4: 143–145.

Graham, D. P. 1967. A training aid on dwarfmistletoe and its control. Unnumbered Rep. U.S. Department of Agriculture, Forest Service, Pacific Northwest Region, Insect and Disease Control Branch. 49 p.

Hawksworth, F. G. 1969. Rapid intensification and upward spread of dwarf mistletoe in inoculated digger pines. Plant Disease Reporter. 53: 615–617.

Hawksworth, F. G. 1977. The 6-class dwarf mistletoe rating system. Gen. Tech. Rep. RM-48. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 7 p.

Hawksworth, F. G.; Geils, B. W. 1985. Vertical spread of dwarf mistletoe in thinned ponderosa pine in Arizona. Res. Note RM-460. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 3 p.

Hawksworth, F. G.; Wiens, D. 1972. Biology and classification of dwarf mistletoes (*Arceuthobium*). Agric. Handb. 401. Washington, DC: U.S. Department of Agriculture, Forest Service. 234 p.

Richardson, K. S.; van der Kamp, B. J. 1972. The rate of upward advance and intensification of dwarf mistletoe on immature western hemlock. Canadian Journal of Forest Research. 2: 313–316.

Scharpf, R. F.; Parmeter, J. R., Jr. 1976. Population buildup and vertical spread of dwarf mistletoe on young red and white firs in California. Res. Pap. PSW-122. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station. 9 p.

Shaw, C. G., III; Hennon, P. E. 1991. Spread, intensification, and upward advance of *Arceuthobium tsugense* after thinning infected young stands of western hemlock in Alaska. Plant Disease. 75. [In press]

Seidel, K. W. 1984. A western larch-Engelmann spruce spacing study in eastern Oregon: results after 10 years. Res. Note PNW-409. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 6 p.

Wicker, E. F.; Wells, J. M. 1983. Intensification and lateral spread of *Arceuthobium laricis* in a young stand of western larch with stocking control. Canadian Journal of Forest Research. 13: 314–319.